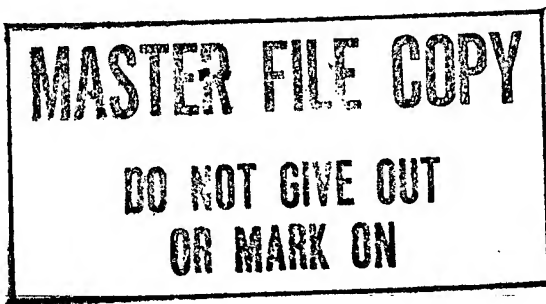




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Secret
SOV UR 82-005
May 1982

Secret

25X1

Contents

	<i>Page</i>	
The Military-Industrial Complex in the USSR	1	25X1
Perspective []		
The Soviet military-industrial complex, the world's largest, has designed and manufactured an array of weaponry that has projected the USSR from a position of military inferiority two decades ago to one now widely perceived as equal to—and in some areas superior to—our own. As new Soviet leaders emerge in the 1980s, however, they will find it increasingly difficult to balance the growing needs of the civilian economy against those of the military-industrial complex. []		25X1
The Military-Industrial Policymaking Process []	3	25X1
In the USSR, military-industrial policy is established by a small group of senior officials, many of whom have long experience with defense issues. The policymaking and planning process is highly secretive, resistant to major alterations in priorities, and imparts considerable momentum to military programs. []		25X1
[]		25X1
Magnitude and Scope of the Soviet Military-Industrial Complex []	7	25X1
The Soviet military-industrial complex is the largest in the world. The nine defense industrial ministries control over 1,500 research, development, and production organizations and receive support from a large but undetermined number of civilian organizations. Several hundred development programs for weapon systems and major system elements are currently under way. []		25X1
[]		25X1

Secret

SOV UR 82-005
May 1982

Secret

25X1

25X1

The Importance of Western Technology to Soviet Defense Industries ☐ 17

25X1

The Soviets have long used Western equipment and know-how, acquired legally and illegally, to accelerate introduction of new weapon components and subsystems. This effort is likely to grow, because many weapon acquisitions programed for the 1980s require manufacturing capabilities that are rare or nonexistent in the USSR. ☐

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Soviet Design and Production Practices in the Aerospace Industries ☐ 23

25X1

Analysis of Soviet development and manufacturing practices for many new aerospace weapon systems reveals an emphasis on simplicity, parts standardization, and generational design inheritance. While these features save resources, increase system reliability, and minimize production problems, they also tend to limit system flexibility and retard Soviet technological progress. ☐

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Comparative Efficiency of Soviet Military Production ☐ 27

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As the Soviets seek more advanced weaponry in the future, they will find it increasingly difficult to afford the large number of weapons they have traditionally procured. The Soviet Union is at a comparative disadvantage to the United States in the production of high-technology military products because of technical and managerial inefficiencies. ☐

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Secret

Secret

			25X1
Other Topics	Metalworking Technology in the USSR: Problems and Prospects	31	25X1
	The Soviets expect better machinery to improve performance in critical sectors of the economy, but their efforts to modernize the metalworking industry are impeded by traditional manufacturing practices as well as by problems with the new technology.		25X1
			25X1
	Western Technology and Polish Production of Military Transport Vehicles for the USSR	37	25X1
	Poland's Huta Stalowa Wola Plant, which has benefited from Western financing and technology since the early 1970s, is now producing a general purpose armored tracked vehicle. The principal user of this vehicle will evidently be the Soviet armed forces.		25X1
			25X1
			25X1
	Soviet Trade Unions: Striking a New Balance	41	25X1
	Events in Poland have caused Soviet leaders to refurbish the image of their own trade unions. Greater weight is being given to improving the workers' welfare, but boosting production still remains the unions' primary responsibility.		25X1
			25X1
			25X1
Briefs	Industrial Production Through April	45	25X1
	New Data on 1981 Hard Currency Position	45	25X1
	Soviet Planner Discusses the Economy	46	25X1
	Large Tungsten Imports Continue	46	25X1
	Soviets Cut Iron Ore Plan	46	25X1
	Regional Commission Claims Success in Improving Management	47	25X1

Secret

25X1

The Military-Industrial Complex in the USSR

Perspective

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The steady increase in Soviet military power since the early 1960s has been sustained by a large and growing defense industry. The USSR's "military-industrial complex" now includes:

- Some 200 major weapon research and development (R&D) facilities.
- About 700 additional facilities that perform at least some defense-related research and testing.
- More than 100 plants for the final assembly of weapons.
- Several thousand production facilities for weapon components and support equipment.

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This far-flung establishment has produced an array of weaponry that has projected the USSR to a military position now widely perceived to be at least equal to—and in some areas superior to—our own. For example, during 1974-80, Soviet defense plants turned out each year an average of 2,850 tanks (compared to 870 for the United States), 900 tactical aircraft (the United States produced about 580), and more than 22,000 surface-to-air missiles (the United States turned out 3,500).

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The momentum of these programs shows every sign of continuing.

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have already identified about 120 development programs for new or substantially modified weapon systems that could be deployed in the 1980s.

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But the development of the Soviet military-industrial complex is not blind or uncontrolled. Rather, it results from the decisions and political choices of the small number of officials who occupy key positions in the party's Politburo and the Defense Council. Led by General Secretary Brezhnev—a

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former overseer of defense industries—these men preside over a policy-making and planning process that is highly centralized, secretive, and resistant to major changes in priorities. The leaders of the Soviet military and defense-industrial establishments—many of whom have worked closely together for decades—have formed political alliances with supporters of civilian heavy industries and have consistently been able to assure priority access to critical resources. [REDACTED]

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These leaders, however, face increasingly difficult choices. The Soviet Union is at a comparative disadvantage to the United States in the production of high-technology military products. To some extent the Soviets have been able to ameliorate the costs of military equipment by an evolutionary approach to weapon design and by acquisition (through both legal and illegal means) of Western technology. Nevertheless, as their economic outlook worsens, Brezhnev and his colleagues will find it increasingly costly to maintain their compact with the military-industrial complex—priority in resource allocation in exchange for political support.¹ [REDACTED]

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This relationship will be further complicated by a leadership succession that will affect not only the top political figures, but the leaders of the military and defense-industrial establishments as well. Thus the continuity in leadership that has been one of the hallmarks of the Soviet military-industrial complex is likely to be jeopardized in the near future. In setting the tone for development of the military-industrial complex, a new leadership will have to balance the needs of the civilian economy against the need to consolidate power by currying favor with the military. [REDACTED]

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The Military-Industrial Policymaking Process ¹

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In the USSR, military-industrial policy is established by a small group of senior officials, many of whom have long experience with defense issues. These officials are advised by the military and several government agencies, which in turn formulate programs, plans, and budgets. The policymaking and planning process is highly secretive, resistant to major alterations in priorities, and imparts considerable momentum to military programs.

Key Officials and Organizations

In the Soviet Union planning and management of all defense activities are highly centralized. The ultimate decisionmaking authority resides with the Politburo, the chief executive body of the Communist Party. The Politburo includes the top officials of both the party and the government and considers the full range of domestic and foreign policy issues. Many of the important decisions on military-industrial matters, however, probably are made by the Defense Council, composed of the half dozen top party and government officials with national security responsibilities. With Brezhnev as its chairman, the Defense Council operates by consensus. The Council of Ministers, in charge of the economy, elaborates policy decisions and is responsible for ensuring that approved military requirements are met.

Policymaking bodies are served by a large number of military, party, and government organizations collectively responsible for planning and oversight of military-industrial activity. Four of these organizations significantly influence policy decisions and exert primary control over their implementation:

- *The Soviet General Staff*, the main executive organ of the armed forces. It apparently serves as the secretariat for the Defense Council—providing the agenda, list of attendees, and decision papers. It

prepares threat assessments that are used to assess defense requirements, and it prepares and defends military plans for the procurement of weapons and related materiel.

- *The Military-Industrial Commission (VPK)*, consisting of the top executives of Soviet defense industries and a supporting staff. The VPK monitors the work of the nine defense industrial ministries and coordinates party and government decisions for the development of major weapon systems. The VPK also closely monitors weapon programs, enforcing schedules and ensuring that technical and performance specifications are met.

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- *The State Planning Committee (Gosplan)*, the national economic planning agency. It is the final technical authority on the ability of the economy to meet overall military needs. It has a military-economic department—manned in part by officers from the General Staff—to represent military interests.

- *The party Central Committee apparatus*, especially the Defense Industries Department. Central Committee departments help government agencies interpret policy decisions when plans and programs are prepared. Departments also maintain independent party channels into all levels of Soviet military and industrial organizations, through which they gather information on compliance with the leaders' directives.

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Officials from these organizations cooperate closely on military-industrial matters. Conflicts are resolved through compromise or, failing that, through appeal to senior officials.

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Organizations that implement decisions—the military services and industrial ministries—can influence policy through their special expertise and control over information. The services originate requirements for

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SOV UR 82-005
May 1982

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new weapon systems, and each competes for missions and resources. Military officers stationed at development and production establishments enforce military claims and maintain high standards of quality control. Industrial officials have information on development and production capabilities not routinely available to the top leaders and planners. Financial and career incentives generally induce them to favor military over civilian programs. However, they have reason to be conservative in all areas, resisting technical innovation or similar measures that could endanger their established production plans. Military programs benefit from the ability of concerned officials—military, party, and VPK—to intervene directly throughout industry to assess capabilities and at least partly counter managerial conservatism. []

Crucial positions at all levels in the military-industrial complex usually are occupied by officials with long experience in defense affairs. Brezhnev was responsible in the party for defense industrial matters before assuming the leadership, and current Minister of Defense Ustinov became a defense industrial manager in the 1930s. Frequently, key officials in planning and management agencies are recruited after successful careers in defense industry or the military, and sometimes they move between major agencies. Important industrial managers, such as weapon designers, usually have long tenure and wield considerable influence in party and government channels. The energy, political skills, and experience of all such officials influence the operation of the military-industrial complex, as do the network of administrative tools at their disposal. []

Plans, Programs, and Budgets

Defense Plans. Soviet defense plans set forth the principal goals and lines of development for military forces. The 15-year perspective defense plans deal with broad goals rather than specific programs. The more detailed five-year and annual defense plans are prepared by the General Staff on the same cycle as the corresponding national economic plans. (Although it presumably is reviewed periodically, the five-year defense plan is not revised and extended each year as is the US Five-Year Defense Plan.) Gosplan and the VPK review the parts dealing with procurement of weapons and other military materiel before the plans are submitted to the Defense Council. []

The five-year defense plan evidently contains a threat projection that identifies foreign military strengths and weaknesses, an analysis of current Soviet military capabilities, and a set of targets for improving these capabilities and meeting the threats. It probably shows projections of military expenditures and manpower requirements and the share of national economic resources that will be required to fulfill the targets. This information would enable the Soviet leaders to assess in general the potential costs of their defense programs. []

Weapon Programs. In drawing up the five-year defense plan, Soviet officials base their targets for acquisition of weapons primarily on development and production programs that are under way. We have considerable information on how the Soviets manage these individual programs. Senior organizations and officials become intimately involved in a program when the weapon is about to enter initial engineering development. By this point the military customer and industrial designer will have agreed on recommended technical approaches and objectives. The remainder of the program is governed by decrees formulated at three decision milestones:

- *The development initiation decision*, made by the Defense Council (or, for minor weapons, by the VPK) on the basis of a proposal by the lead designer. The decree authorizes development from the design phase through the fabrication of test prototypes and identifies the major participating organizations. At this point the effort gathers momentum. The Soviets decide on a single design and freeze the system's basic technology.
- *The production preparation decision*, made by the same officials who initiated the program. This decision finalizes the commitment to production and often precedes full-scale testing. Heavy resource commitments may be required to expand or build facilities. It then becomes extremely difficult to halt a program, except by resort to a high-level political decision.

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- *The production and deployment decision*, made near the end of the test program. Senior defense, industrial, and economic planning officials take part in this decision. Again, major systems may require explicit approval by the Defense Council. []

Economic Plans. The production needed to meet all civilian and military requirements, including those of weapon programs, is organized and directed by economic plans. Five-year and annual economic plans establish production targets, and annual plans allocate the material resources necessary to meet these targets. Although the economic planning process affords the best opportunity to assess military- and civilian-industrial trade-offs, planning procedures limit the ability of decisionmakers to make such comparisons. []

Gosplan and other agencies participating in economic planning do not have the technical capability to compare all potential resources applications when making plan assignments. Instead, Gosplan tends to allocate resources sequentially. In plan preparation, it services military requirements first, relying on its military-economic department to develop the specific production and supply relationships within the defense industries. Once they are established, officials resist adjusting economic plans because each change requires further changes throughout complex networks of production and supply relationships. When plans must be adjusted, Gosplan tends to apportion available resources according to the priority of the user, again favoring the military. []

The military also has several advantages in disputes with civilian interests. Because of security considerations, civilian economic planning officials usually cannot learn of, much less challenge, specific military-industrial use of resources. When challenges do arise, political considerations rather than hard economic criteria usually govern decisions. General Staff and other defense officials have wide access to civilian industrial plans. They participate and wield considerable influence in the resolution of disputes over resources. []

Implications for Future Defense Programs

Although our understanding of Soviet military-industrial planning and decisionmaking is incomplete, we know the process has a number of characteristics that

must be considered in assessments of the future Soviet defense effort:

- It is highly centralized. Top leaders are drawn into the details of military plans and programs and are personally responsible for their success or failure.
- Decisionmakers on military affairs have long tenures. This gives their policies continuity and consistency.
- Few officials know the details of defense plans and budgets.
- There is little incentive to review basic priorities. Fundamental national policy reviews are required only at five-year intervals, when national economic plans are prepared.
- It does not facilitate thorough scrutiny of military programs in terms of civilian alternatives. Moreover, budgets specify the organizations that receive funds, but not necessarily the functions for which funds are to be spent. This makes it difficult to identify waste and duplication.
- It is resistant to major alterations in plans and programs. Once development of a weapon begins, usually only a technical failure or an explicit high-level decision can cancel the program.

- It promotes gradual change. At every level in the system, success is measured by fulfillment of goals, goals are set conservatively, and risk is discouraged. This results in an evolutionary approach to weapon development, wherein improvements are incorporated incrementally in successive generations of weapons. []

These characteristics of Soviet decisionmaking impart considerable momentum to military programs. They limit the ability of civilian claimants (except at the highest levels of the leadership) to challenge the military's priority access to resources. And they promote a basic continuity in the development of Soviet military power, barring radical changes in the external or internal environment for decisionmaking. []

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Magnitude and Scope of the Soviet Military-Industrial Complex

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The Soviet military-industrial complex is the largest in the world and the instrument through which Soviet leaders have conducted a vigorous, broad-based build-up of their military forces over the past two decades. It has demonstrated a capacity to develop some 140 new or substantially modified systems per decade. Several hundred development programs for weapon systems and major system elements are currently under way.

Allocation of Resources

The Soviet military-industrial complex has grown and prospered because of the high value which the political leadership has placed on the role of military power to defend and advance state interests. The leadership enforces decisions regarding the allocation of resources for the development and production of military equipment through the Soviet command economy, which is designed to be responsive to leadership goals. Soviet officials have stated on numerous occasions that they will provide whatever level of resources is necessary to achieve and preserve military equivalence with the West.

To achieve its current position, the Soviet military effort has, since the early 1960s, required ever-increasing expenditures. Although these costs represent a significant portion—13 to 14 percent—of the Soviet Union's national product, they have an even greater impact on certain key sectors of the economy. We estimate that about one-third of the output of the machine-building and metalworking sector, one-fourth of the output of all metallurgy, and about one-fifth of total energy production is consumed by the military-industrial complex. Critical labor and capital resources are siphoned off to support development and production programs for weapon systems. These programs add little to the continued growth of the economy.

Organization

Most of the organizations that make up the military-industrial complex belong to one of the nine ministries identified by the Soviets as the defense industrial

ministries. About one-third of all Soviet R&D manpower is assigned to these ministries. Each is responsible for the development and production of specific types of military products (see table). Together they control over 1,500 separate R&D and production organizations.

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Basic and applied research is undertaken primarily by scientific research institutes (NII), while design, development, and engineering are usually the responsibility of design bureaus. The production of military products is carried out by plants assigned to the ministries.

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The Soviets have about 200 major weapons R&D facilities. An additional 700 facilities perform defense-related R&D as well as testing. About 20 fully equipped test sites perform final system testing and acceptance, and some 75 smaller sites conduct initial system and component testing. Over 100 final assembly plants manufacture the bulk of major weapon systems. These production facilities are supported by several thousand producers of major components and combat support equipment.

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The Civilian Connection

Although most of the effort of the nine defense industrial ministries is devoted to the development and production of military products, a portion of their resources is set aside for civilian production. At the same time, the complexity of modern weapon systems requires that an increasing number of organizations from the civilian industrial ministries and the national and regional academies of science become involved in military programs. The civilian organizations support the defense industrial ministries by conducting basic and applied research and by supplying materials, components, and parts. They make major contributions to defense production in areas such as solid propellants, laser weapon components, military vehicles, electronic warfare equipment, and communications satellites. Although we do not know how many

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SOV UR 82-005
May 1982

Secret**Principal Military-Related Products of Selected Industrial Ministries in the USSR**

Defense Industrial Ministries	Products
Ministry of the Aviation Industry	Aircraft, aerodynamic missiles, spacecraft, air-to-air missiles, defensive missiles (both tactical and strategic), tactical air-to-surface missiles, and ASW missiles.
Ministry of General Machine Building	Liquid- and solid-propellant ballistic missiles, including submarine-launched missiles (SLBMs); SLBM fire-control systems; space launch vehicles; spacecraft; and surface-to-surface cruise missiles.
Ministry of the Defense Industry	Conventional ground force weapons, mobile solid-propellant ballistic missiles, optical systems, antitank guided missiles, tactical surface-to-air missiles, lasers, and ASW missiles.
Ministry of the Shipbuilding Industry	Naval vessels, naval electronic and support systems, mines, torpedoes, submarine detection systems, acoustic naval systems, and radars.
Ministry of the Radio Industry	Radars, communications and navigation equipment, special purpose computers, guidance and control systems, and lasers.
Ministry of Medium Machine Building	Nuclear weapons and high-energy lasers.
Ministry of Machine Building	Conventional ordnance, munitions, fuzes, and solid propellants.
Ministry of the Electronics Industry	Electronics parts, components, and subassemblies.
Ministry of the Communications Equipment Industry	Communication equipment, radar components, electronic warfare equipment, military computers, and facsimile equipment.
Other Key Defense-Related Industrial Ministries	
Ministry of the Automotive Industry	Trucks, armored personnel carriers, and transporters.
Ministry of Heavy and Transport Machine Building	Armored vehicles, diesel engines, and generators.
Ministry of the Electrical Equipment Industry	Batteries, electrical components, communications equipment, radar components, and biological/chemical warfare detectors.
Ministry of Instrument Making, Automation Equipment, and Control Systems	Computers and instrumentation control systems.
Ministry of Power Machine Building	Generators.
Ministry of the Chemical Industry	Fuels, fiberglass components for rocket motors, propellants, chemical warfare materials, and plastics.
Ministry of Tractor and Agricultural Machine Building	Tanks and tracked vehicles.
Ministry of the Petroleum Refining and Petrochemical Industry	Tires, rubber, fuels, lubricants, and clothing.

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organizations fall within this category, we believe the number is large, possibly exceeding the number of facilities in the defense industrial ministries.

of steel, industrial explosives, transportation machinery, tractors, machine tools, and industrial electronics in a variety of the defense industrial ministries.

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The extent to which the defense and civilian sectors are interrelated was suggested by President Brezhnev when he claimed that 41 percent of the output of the "defense industries" went for civilian production. He presumably was referring primarily to the production

Joint production of military and civilian goods is crucial to Soviet industrial mobilization planning. The Soviet belief that a high level of national preparedness is a prerequisite for military victory extends throughout the military-industrial complex. Mobilization

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plans for Soviet defense plants call for increasing military production by curtailing civilian production, consolidating military product lines, relaxing quality control standards, increasing the number of shifts, and using existing plant and equipment more intensively. Industrial mobilization plans, which normally cover the first year of conflict, are generally supported by dedicated reserve stocks of raw materials and components at defense plants. In addition, a number of civilian plants are slated for conversion to military production during wartime. [REDACTED]

Weapon Development Strategies

Technology transfer—either legal or illegal—has been significant in allowing the Soviets to field better weapon systems at less cost. An overwhelming proportion of their new weapon system development programs have benefited from Western technology. This dependence on Western technology is a testament to the USSR's technological lag in weapon systems development and to the inefficiencies in both the R&D and production sectors of the military-industrial complex. Even when the Soviets incorporate Western technologies, the quality of the military product seldom exceeds—and often does not equal—that of the West. The Soviets tend to compensate for technological limitations by producing large quantities of weapons, since this quality-quantity trade-off is a viable military alternative for many types of weapons. (For additional detail and examples, see "The Importance of Western Technology to Soviet Defense Industries" in this issue.) [REDACTED]

Technological deficiencies also lead Soviet weapon developers to emphasize evolutionary advances in military technology characterized by incremental improvements applied to existing systems. In the few instances when the Soviets have tried to achieve major advances in military technology, they have committed resources on a massive scale and persistently pursued the task over decades. Their continuing effort to develop solid-propellant strategic missiles comparable to the US Minuteman and the Polaris is a case in point. (For additional detail and examples, see "Soviet Design and Production Practices in the Soviet Aerospace Industries" in this issue.) [REDACTED]

Outlook

Although the military-industrial complex has been largely successful in developing the weapons required to meet the military objectives of the leadership, it is likely to have considerable difficulty maintaining its momentum through the late 1980s. The development and production of weapons for the current military force has been largely at the expense of broad technological development in the civilian sector. Weapon systems now in development or planned for this period will require additional infusions of advanced technology. Yet the Soviets are now entering a period in which productivity gains in the civilian sector must also come through technological improvements, thus raising the opportunity cost (alternative return) of maintaining the defense sector's high priority in the use of those high-quality resources required to generate advanced technology. [REDACTED]

In the past, expansion of floorspace at R&D establishments and production facilities has been a good indicator of future Soviet defense effort. [REDACTED]

[REDACTED] Unless the Soviets terminate major programs now in the R&D stage or reduce the number of systems they plan to produce, they must be prepared to support continued expansion of the defense sector at least at historical rates of growth until the mid-1980s. Any immediate retreat from current trends would probably be exceedingly difficult for the present leadership—given the immense resource allocations already committed to programs now under way. [REDACTED]

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The Importance of Western Technology to Soviet Defense Industries

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For over three decades, Soviet defense industries have relied on Western technology to accelerate innovation in weapon R&D and production. Although largely self-sufficient, Soviet defense industries routinely use proven Western R&D approaches to shorten weapon leadtimes. Also, Western manufacturing know-how and equipment—obtained legally and illegally—permit production of key weapon components many years sooner and often reduce production costs by increasing efficiency. Acquisitions have increased since trade with the West opened up in the early 1970s. Soviet legal and clandestine efforts to obtain Western technology have become larger, more sophisticated, and better managed.

The acquisition effort is likely to increase during the 1980s and to focus heavily on manufacturing technologies. Future military requirements dictate an increasingly sophisticated weapons mix that requires production of many advanced component and subsystem technologies. Resort to Western expertise and equipment offers Soviet defense industries the best opportunity to rapidly develop the necessary manufacturing capabilities. Economically, it can make the defense industries more efficient and thus better able to cope with worsening shortages of labor and materials in a faltering economy. But greater recourse to Western technology will increase the risk of technological dependence on the West and worsen an already poor Soviet hard-currency and credit outlook.

Impact on Weapon R&D

Soviet designers evaluate samples of Western military hardware to develop effective countermeasures and select specific designs useful for their own weapons. They often use proven Western design solutions and test data to eliminate the preliminary stages of research in weapon R&D. For projects in the earliest stages of R&D, this practice probably can shorten leadtimes of more than a decade needed to field a new weapon by two to five years. Table 1 summarizes technologies that have greatly benefited the Soviet weapon R&D effort during the past decade.

The USSR's use of Western technology in its weapon R&D effort is both cost effective and low risk. Savings achieved by using proven Western technical approaches to compress weapon R&D cycles probably outweigh severalfold the costs of legal and clandestine acquisition. Failure to obtain specific equipment or know-how can delay introduction of more advanced component technologies for several years. But a lack of Western technology rarely, if ever, forces the Soviets to stop or forgo development of a weapon.

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Soviet developers prefer improving selected components to adopting completely new designs without technological predecessors. Therefore, less sophisticated but proven component technologies can usually be substituted when new technologies are not available. Even if the lack of a critical technology were to force the Soviets to stop or forgo a weapon development program, relatively few resources would be wasted. Decisions regarding the technologies that weapon components will include are made early in the development cycle, before large amounts of manpower and capital are invested in preparations for full-scale engineering development, testing, and production.

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Impact on Weapon Production

The infusion of Western manufacturing approaches into Soviet defense industries has become increasingly important since the early 1970s. Know-how and equipment acquired are carefully selected to bridge technological gaps between Soviet weapon R&D advances and relatively backward manufacturing capabilities. Technology from the West has enabled defense plants to implement relatively advanced manufacturing approaches—so important to production of increasingly sophisticated Soviet weapons—many years before indigenous capabilities could be developed.

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SOV UR 82-005
May 1982

Secret

Table 1

**Key Military-Related R&D and Manufacturing Technologies
Acquired From the West During the 1970s**

Technologies	Equipment and Know-How Acquired
Computers and microprocessors	Complete systems, software and ancillary equipment, computer-aided design and test programs, minicomputers, avionics, and fire-control systems for Western weapons.
Machine tools and industrial robots	Multiaxis NC and CNC tools, NC machining centers, transfer lines, gear cutters, grinders, rotary forges, heavy hydraulic presses, welding robots, and quality- and process-control equipment.
Metallurgy	Ultrapure metal and alloy refining techniques, powder metallurgy, induction and vacuum-arc furnaces, automated casting and molding lines, and nondestructive test and quality-control equipment.
Chemicals and petrochemicals	Polymers and adhesives for composite materials; photoresist chemicals and films; adhesives and binders; lubricants; and turnkey plants and processes for polymers, synthetic rubber, and other products.
Microelectronics	(See table 2.)
Signal processing	Seismic streamers, acoustic spectrum analyzers, underwater navigation and direction-finding equipment, and recording devices.
Guidance and navigation	Inertial navigation components; laser gyros; and guidance components for air-to-air, surface-to-air, and ballistic missiles.
Electro-optics	Low-light television, image-intensification technology, night vision devices, electro-optical sights and trackers, laser rangefinders, and US reconnaissance satellite technology.
Radars	Terrain-following and airborne-intercept radars and SAM radar antenna technology.
Propulsion	Nuclear submarine, diesel-automotive, and aircraft propulsion.
Materials	Ultrapure refining techniques and composite materials.

The use of Western manufacturing processes and equipment enables the Soviets to achieve higher production rates with less labor and scrap and thereby to reduce production costs. Metal savings are important, since Soviet defense industries consume about one-fourth of all metallurgical output. Table 1 shows manufacturing technologies that have greatly contributed to accelerated technological growth in Soviet defense industries. []

The acquisition of microelectronics equipment and know-how is the most striking example of Soviet resort to Western manufacturing technology. Over the past decade, the ability to make high-quality microelectronic components has become increasingly important to the production of advanced guidance components for missiles and precision-guided munitions. Microelectronics are also important for production of minicomputers and microprocessor devices for modern airborne radar, fire-control, and electronic

warfare systems. Their production, however, required manufacturing and fabrication techniques that were not widely available in the USSR. To fill this gap, the Soviets acquired Western microelectronics manufacturing technology valued at hundreds of millions of dollars (see table 2). Much of this was military-related technology clandestinely obtained. []

Western multiaxis numerically controlled (NC) machine tools also have important uses in Soviet defense industries. Many advanced weapon components, such as microbearings for missile guidance, require precise tolerances and complex geometries producible only with flexible NC tools, which are often computer assisted. Poor-quality electromechanical components and inadequate minicomputer technology limit the development and production of domestic NC tools. []

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Table 2

**Examples of Western Microelectronic Equipment and Technology
Acquired by the Soviet Bloc**

Manufacturing Technology	Equipment Acquired
Process technology for microelectronic wafer preparation	Over 400 pieces of equipment related to wafer preparation, including epitaxial growth furnaces, crystal pullers, rinsers/dryers, slicers, and lapping and polishing units.
Process technology for producing circuit masks	More than 60 processing techniques including computer-aided design software, pattern generators and compilers, digital plotters, photorepeaters, contact printers, mask comparators, electron-beam generators, and ion milling equipment.
Equipment for device fabrication	Nearly 700 mask aligners, diffusion furnaces, ion implanters, coaters, etchers, and photochemical process lines.
Assembly and test equipment	Nearly 200 items including scribes, bonders, probe testers, and final test equipment.

Soviet defense industries have also benefited substantially from legal purchases of large numbers of general purpose machine tools. Frequently, conventional Soviet machine tools such as gear cutters and grinders cannot provide the precise tolerances that many modern Soviet weapons require. Roughly three-fourths of the some \$4 billion the Soviets spent for Western machine tools during the past decade went for conventional general purpose tools. Custom-designed machine tools from the West are also critical to defense products.

Metallurgical manufacturing capabilities in Soviet defense industries also lean heavily on Western equipment and know-how. Automated casting lines obtained from the West are used in high-rate production of military automotive components such as engine blocks, brake cylinders, and wheel drums. Access to Western metallurgical technology has also reduced Soviet dependence on imports of specialty steels, which are used extensively in military products. An array of electric furnaces from the West process specialty steels used for such products as tank armor and artillery gun tubes. Most of these processes also tend to conserve metal.

Acquisition of Western production technology, however, is costly, and the Soviets are often unable to properly install and operate Western equipment without onsite assistance from the West. Legal or illegal

acquisition of Western manufacturing equipment and know-how normally require large outlays of hard currency and capital many years before new equipment becomes productive. Because Western manufacturing technologies are often more advanced than those in the USSR, the customer does not always have the know-how required for proper use of the equipment or processes purchased. For example, Western machining centers often require higher quality castings for workpieces than many Soviet foundries can provide. In addition to proper tooling, efficient manufacturing operations require an understanding of how complex materials processing, machining, and fabrication activities interrelate. This know-how is commonly gained by the vendor largely through years of trial and error.

Outlook Through 1990

Soviet military requirements through 1990 dictate an increasingly sophisticated weapons mix. Successful development and deployment of many of these new weapons hinge on advanced component technologies. A number of key military technologies currently available or now emerging in the West will offer the Soviet weapon R&D establishment substantial opportunity to master these critical weapon component technologies more rapidly. Acquisition of Western microelectronics, in-flight guidance computers, US inertial components, signal-processing techniques, composite materials, and computer-aided design

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Table 3

**Key Military-Related R&D and Manufacturing Technologies:
Priority Requirements for the 1980s**

Technologies	Equipment and Know-How Targeted
Computers and microprocessors	Computer-aided design (CAD) techniques and equipment, random access memory, all categories of production equipment and know-how.
Machine tools and industrial robots	Multiaxis NC and CNC tools, NC machining centers, transfer lines, and process- and quality-control robots.
Metallurgy	Ultrapure metal and alloy refining techniques; process- and quality-control technology; hot-isostatic and isothermal pressing technology; and powder metallurgy technology including: reduction furnaces, sievers, ballmills, and process- and quality-control methods.
Chemicals and petrochemicals	Polymers and adhesives for composite materials, high-energy fuels, solid-propellant processing, high-temperature lubricants, photoresist chemicals and films, adhesives, manufacturing technology for hydraulic fluids, motors, and flexible tubing.
Signal processing	Signal-processing techniques for detection and discrimination and digital imagery processing techniques.
Guidance and navigation	Advanced inertial guidance components, algorithms and software for guidance calibration, and in-flight guidance computers.
Electro-optics	Forward-looking infrared (FLIR) technology and electro-optical sights and trackers.
Radars	Synthetic-aperture, phased-array, and programmable airborne radar technology.
Propulsion	Aircraft engine technology, automotive electric drive technology, vehicular turbine technology, and digital power control systems.
Materials	Manufacturing and design techniques for carbon-carbon, Kevlar-like, and other composite materials.

(CAD) probably have highest priority. Table 3 shows other key R&D-related technologies we believe the Soviets will seek during the coming decade. []

The acquisition effort probably will focus increasingly on Western manufacturing equipment and know-how in the coming decade. Many of the manufacturing approaches that production of new weapon component and subsystems technologies require are currently rare or nonexistent in the USSR. For example, the Soviets probably will rely on Western technology for expansion of their microelectronics production capabilities. The USSR is currently seeking US help to build two or three plants to produce polysilicon materials suitable for military applications. It is also highly interested in emerging technologies related to very-high-speed integrated circuits. []

The Soviets have begun to acquire Western equipment and know-how to improve the quality of their metal powders and sintered products. This will enable the USSR to develop and produce tungsten-based heavy-alloy penetrators for improved kinetic-energy antitank rounds. Similar powder metallurgy processes can be used for advanced high-temperature turbine blades necessary for more fuel-efficient military aircraft engines. The Soviets are also seeking large-capacity hot-isostatic press (HIP) technology. HIP technology has a variety of applications in aerospace ranging from hot-stage turbine components for aircraft engines to structural components. Another likely target for Soviet acquisition is isothermal pressing technology, which allows large structures to be cast as a single piece. []

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The Soviets will also seek many other less exotic manufacturing technologies to enable their defense industries to produce higher quality products at lower costs. For example, they hope to build a plant to produce electric drives for heavy equipment with Western help. Electric drives can also be used for large missile transporters. The Soviets have difficulty producing reliable hardened electric motors suitable for military use and are seeking manufacturing technology in the West. Also, the poor quality of Soviet adhesives, high-temperature lubricants, and hydraulic fluids underlies Soviet efforts to improve these manufacturing capabilities through Western know-how and equipment. [REDACTED]

Using Western technology to sustain the growth of technological competence in Soviet defense industries also will yield economic benefits. A faltering economy makes the Soviets increasingly aware of the costs of sustaining defense production. The labor pool will continue to decline and the outlook for steel production is bleak. This makes it even more likely the Soviets will continue to seek Western manufacturing approaches, which are substantially less labor intensive and consume less metal than counterpart Soviet processes. [REDACTED]

Large purchases of Western manufacturing equipment and know-how, however, would worsen the already poor hard currency and credit outlook for the USSR over the next several years. Consequently, the Soviets are likely whenever possible to rely on clandestine acquisition, especially to meet the needs of the Soviet weapon R&D community. Military researchers and weapon designers generally seek specific know-how or hardware to relieve a particular technological bottleneck. Industrial needs, however, are more substantial and usually require hard currency outlays. The necessary processes and machine tools are difficult to obtain by clandestine means. [REDACTED]

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Soviet Design and Production Practices in the Aerospace Industries

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The predominant Soviet design philosophy for new aerospace weapons—ICBMs, SAMs, aircraft, and space systems—is an evolutionary approach that results in significant development and production cost savings but may increase total life-cycle costs. This philosophy stresses (1) extensive design inheritance between systems and gradual incorporation of new technologies; (2) development of single-mission systems; and (3) development of systems that are easy to manufacture, operate, and maintain, using to the extent possible off-the-shelf components even for systems with different missions. Such practices are imposed by the limitations of the Soviet industrial base, and while they can reduce development and procurement costs and enhance export appeal on Third World markets, they also limit flexibility and system performance. There is some evidence that the Soviets are moving toward more technologically advanced systems designed for multipurpose roles. Such attempts in the past have resulted in somewhat longer, more expensive development cycles.

Design Inheritance

Soviet designers stress the use of existing systems, subsystems, and components whenever possible, incorporating new technologies only where mission requirements for greater performance or reliability require them to do so. Most Soviet space systems, for example, evolved from a few basic spacecraft designs. New systems hardware is integrated with common spacecraft components and subsystems to meet new mission requirements. All Soviet photoreconnaissance satellites are modifications of the early Vostok and Soyuz manned spacecraft with the life support systems removed. The required optical components are incorporated into operationally proven capsules and series-produced launchers, a practice that significantly reduces the time and expense of developing a new satellite.

The use of the same components in systems for different missions or services is also prevalent. The AS-5 air-to-surface missile shares several major components and subassemblies with the SS-N-2 naval

cruise missile. Combined production of the two missiles currently exceeds 30,000 units. Such a large production run substantially reduces unit cost. If our current estimate of AS-5 production is correct, the Soviets have already saved the ruble equivalent of about \$100 million—enough for 300 additional missiles—by using common components. Most Soviet naval SAMs are ship-based versions of ground systems. Because of the extensive commonality between ground and naval systems, Soviet naval SAMs cost an average of 60 percent less for research, development, test, and evaluation (RDT&E) than the ground versions on which they are based.

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This evolutionary design approach also frees resources for other purposes and eliminates the time and risk involved in the research and application of wholly new technology for all elements of a system. Resources are then concentrated on the development of any new technologies critical to a specific mission.

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The design inheritance approach has sometimes been carried to the extreme—with catastrophic results. In response to the US challenge to land a man on the moon, the Soviets began development of a large space booster, the TT-05. They chose to simply increase the number of dated conventional liquid engines rather than develop the higher energy liquid cryogenic engines used in the US Saturn V. Acoustic disturbances and vibration destroyed three prototypes before the program was eventually canceled in 1974.

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Soviet weapons are generally designed to perform a single, limited role. They are then integrated with other complementary systems to meet overall mission requirements. An example is the SA-6, which was designed for use with the SA-4 and SA-9 in a tactical role to provide air defense for Soviet ground forces. The SA-6 is intended for medium-range intercept of high-performance aircraft, while the SA-4 and SA-9 are for intercepts at the long and short ranges, respectively. Because of reduced design complexity, individual systems can be fielded in large numbers and as long as the perceived threat or need exists. For example, the multitude of single-purpose SAMs, including the SA-1, deployed over the past three decades are still in use, although new technologies have been gradually incorporated through modifications to improve their performance and enhance their capability against the current air threat. [REDACTED]

Although Soviet aircraft can perform various missions, they are optimized for a single role. The MIG-25 interceptor was designed and deployed, in conjunction with the SA-5, to defend against high-altitude, high-performance strategic bombers. Even though the US high-altitude bomber development program was canceled, the Soviets continue deployment of both systems as a defense against future threats. [REDACTED]

An exception to this single-mission design practice is the SA-10. This new SAM appears to be designed for a multimission role and is expected to perform well against aircraft at all altitudes. With an overall design inheritance factor of only about 5 percent, it cost more than twice as much to develop as any other Soviet SAM. [REDACTED]

Design Simplicity

In general, Soviet weapons reflect a commitment to functional designs that can be easily manufactured in labor-intensive factories and readily maintained in the field with a minimum of technical skill. Soviet weapons designers do not face the competitive pressures that drive Western designers to press the state of the art. Rather, Soviet designers are required to adhere to industry standards, use off-the-shelf components, and

employ the preferred design and manufacturing methods detailed in official design handbooks to ensure producibility, maintainability, and ease of operation. Relatively crude finishes and tolerances are generally used where performance will not be impaired, but meticulous manufacturing and quality control are undertaken where necessary. Circuit designs are simple by US standards and contain a limited variety of components. The use of exotic materials, which are costly and often difficult to machine, is also kept to a minimum. [REDACTED]

The R11-F-300 jet engine used in the MIG-21 fighter contains only 2,500 parts, approximately one-ninth the number in a comparable US engine. A US jet engine manufacturer has estimated that the Soviet engine could be manufactured for 60 to 70 percent less than a comparable US engine. Most of this savings results from simplified engine design specifications, the use of less exotic materials, and selective finishing. (In contrast, US engines tend toward costly, higher quality finishes for primarily cosmetic reasons.) The engine inlet duct, for example, is highly finished only at the leading edge where airflow is significantly affected, but farther back in the duct, fastener heads protrude above the surface. Variants of this engine have also been used by the Yakovlev and Sukhoy design bureaus for the YAK-28 and the SU-15. [REDACTED]

Design simplicity increases reliability while reducing development and production costs. In addition, because simpler systems are easier to maintain and require fewer types of components as spares, they are more attractive on Third World export markets, where skills are at a premium. [REDACTED]

Reliability

System reliability is achieved through redundancy in critical subsystems, the use of proven components produced in large quantities, and simplified field maintenance procedures. [REDACTED]

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Components that have proved reliable in an operational environment continue to be used in a variety of systems, thus avoiding lengthy qualifications testing of newly developed and manufactured hardware.



Another design practice used to increase system reliability is the inclusion of numerous easily accessible test and adjustment points to offset the difficulties with commercial-grade components. For example, the entire nose section of the Foxbat aircraft rolls forward to permit easy access to the avionics system. Examination of the SA-2 and SA-3 SAM systems revealed metal plates engraved with the appropriate waveforms attached at test points to simplify critical adjustments. Routine preventive maintenance checks are designed to detect potential problems, and test points are typically monitored to determine if an associated potentiometer can be adjusted to obtain prescribed tolerances. If not, corrective action is taken. The inclusion of slide-out equipment racks also precludes the need for complex test equipment, permits in-circuit troubleshooting, and minimizes requirements for trained technicians in the field.



Equipment that cannot be readily repaired in the field is replaced and returned to rear-echelon repair facilities where skilled maintenance personnel are concentrated. As a result of these practices, annual maintenance costs for the Soviet SA-2 are approximately one-half those for the US Nike Hercules. However, total life-cycle costs for Soviet systems may be greater because of maintenance and replacement costs over extended lifetimes.



Limitations of Industrial Base

The Soviet predilection for an evolutionary design philosophy is more a matter of necessity than choice. Labor-intensive production and the failure to master precision and automated production technologies limit the designer's freedom. Current Soviet plants have difficulty producing weapon systems that incorporate complex new technologies. Soviet designers try to overcome these technological limitations through innovative combinations of proven components and adequate substitutions of a lower technology solution for a higher risk, advanced technology—for example, the use of hybrid computers in lieu of digital computers.

The Soviet state of the art in missile production lags that of the United States in several areas. The Soviet production base is geared to manufacturing with loose tolerance, whereas certain advanced technologies require precision techniques. Totally solid-state guidance mechanisms required for onboard digital computer functions necessitate precision manufacturing capabilities, skilled assembly operators, and advanced test equipment. The test equipment currently used in US subassemblies is completely computerized and more advanced than anything known to be within Soviet capabilities. The components required to build the test equipment consist primarily of the same solid-state devices necessary for the final product. These weaknesses in microelectronics production capabilities have inhibited Soviet designers from across-the-board reliance on digital guidance systems. The software requirements for onboard digital systems and automated production controls are another Soviet weakness—one which affected accuracy and readiness in older ICBMs.

Extensive reliance on design inheritance also inhibits rapid Soviet responses to military problems that require innovative solutions. When the Soviets attempt to meet new strategic challenges with advanced technology, they make early commitments of resources and persistently pursue the objective in spite of failures. Technical problems with advanced solid propellants prolonged the preflight development stage of the new medium solid-propellant ICBM from the usual

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seven or eight years to about 14 years. The Soviets probably benefited from data on the Concorde in developing their own SST, the TU-144, but they failed to fully understand advanced Western industrial materials and processes and the complex thermodynamic stresses associated with sustained supersonic flight. Although development began in 1962, the TU-144 has not yet entered service. The most pronounced success with advanced technology has been the A-class submarine, although the development program lasted over 20 years. Development and production costs far outstripped those of other torpedo attack submarines. [REDACTED]

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On balance, however, these design policies have served the Soviets well by making most individual military systems more affordable and enabling them to produce large numbers of items to meet most of their military needs. In addition, expanding production to meet export demand in Third World markets further lowers their own unit costs. [REDACTED]

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Comparative Efficiency of Soviet Military Production

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As the Soviets seek more advanced weaponry in the future, they will find it increasingly difficult to afford the large number of weapons they have traditionally procured. The Soviet Union is at a comparative disadvantage to the United States in the production of high-technology military products. This is due to deficiencies in Soviet production machinery and techniques as well as inefficient managerial practices. The more technologically complex the weapon system is, the greater the disadvantage. []

Reasons for Higher Cost

Advanced technology represents a real challenge to the manufacturing capabilities of most Soviet plants. The manufacturing base is backward and has difficulty in meeting requirements for close tolerances, high reliability, "clean" production facilities, and production of defect-free materials. To compensate for these deficiencies, Soviet plant managers must often employ expensive manufacturing techniques:

- To obtain the required number of acceptable high-quality electronic components, managers will often have large production runs from which a batch of quality components are selected. The high reject rates result in higher overhead costs.
- To obtain more durable metal parts required in modern weaponry, the Soviets have employed powder metals, but have had to cope with problems resulting from flaws and impurities in these metals. While such advanced processes as hot isostatic pressing techniques may be used, poor materials increase the number of rejected parts and hence the cost of parts fabrication.
- Implementing advanced weapon designs with unsophisticated, labor-intensive production practices raises both labor and materials costs. For example, to achieve the desired performance characteristics of the SA-6 SAM radar, the Soviets had to depend on a large number of vacuum tubes and labor-intensive wiring methods. []

The higher relative cost of advanced military weapons is also probably partly due to poor industrial management and perverse incentives. Because plant managers have a strong incentive to fulfill gross output plans regardless of cost, they inflate cost accounts by hoarding material, spare parts, and machinery as insurance against the risks and uncertainties of installing and mastering advanced technology. New products and processes make it more difficult to fulfill routine production plans and to meet scheduled deadlines found in the Soviet leadership decrees that launch new weapons development programs. Yet plan fulfillment is critical for the payment of worker bonuses and the advancement of the careers of senior managers. []

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[] Soviet bookkeeping allows these practices to persist, even in defense plants. For example, the Scientific Research Institute of Automation in Leningrad reportedly needed only 15 engineers from its 100-man production engineering staff to monitor ongoing production of airborne computers. Occasionally they needed 30 more to put a new product into production. Thus between 55 and 85 retained for contingencies were inactive at various times and their wages only added to the overhead costs of production. []

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Evaluation of Relative Efficiency

The Soviet disadvantage in the production of high-technology weapons can be roughly measured in economic terms by a comparison of what it costs the Soviets in rubles to produce various items and what it would cost in dollars to manufacture the same products in the United States. If Soviet manufacturing efficiency were the same at the different levels of technology—from the conventional to the advanced—there would be no marked difference in the ruble-dollar ratios as technological complexity increased. Our calculations suggest, however, that the disparity

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between the ruble costs for high-technology and conventional-technology production in the USSR is much greater than the difference in corresponding dollar costs in the United States (see chart):

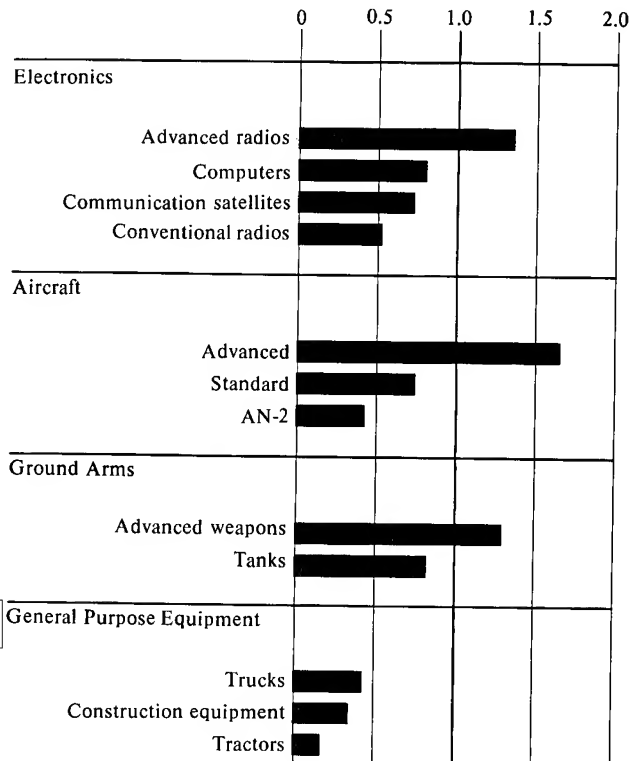
- For each dollar that would be spent in the United States to produce a conventional radio set, the Soviets would spend about .50 rubles. But for each dollar spent in the United States to produce a communications satellite ground station, the Soviets would spend .70 rubles or about 40 percent more in relative terms.
- For each dollar that would be spent in the United States in producing military fighter and transport aircraft, the Soviets would spend an average of about .70 rubles or about 70 percent more relative to the conventional AN-2 light aircraft employed for both military and civilian uses.

The disparities are even greater for the production of military items embodying more advanced technology than those noted above. For example, the cost to the Soviets of producing state-of-the-art aircraft averages over 1.5 rubles per dollar—more than twice the relative cost of the average fighter or transport.

These figures provide an approximate measure of the Soviets' comparative disadvantage. Possible future refinements of the estimates may yield different numerical results but probably will not affect the basic conclusion regarding the comparative disadvantage. This disadvantage is a function of the inefficiencies of the defense industries and management practices, which are magnified as production technology increases. The ruble-dollar ratios cited only provide a tool to index these inefficiencies.

Relative Resource Costs of Soviet Military Equipment

Ruble/Dollar Cost Ratio^a



^aRatio of the ruble cost (1970 rubles) of a military product to its dollar value (1975 dollars) if it were produced in the United States.

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Impact on the Military

A variety of pressures—foreign military threats, international political considerations, and concerns about prestige—have operated over decades to produce strong military demands for more advanced technologies in areas such as microelectronics. Thus the technological level of Soviet weaponry has been increasing constantly. Because of the relative backwardness of Soviet industry—particularly regarding high-technology production—the Soviets have sought to keep up with the United States by using an evolutionary approach to weapons development and the considerable design inheritance from system to system that results. Their emphasis on acquiring foreign technology for military programs is a reflection of this technological backwardness.¹ []

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The Soviets probably expect the relative burden of high technology to grow as they are driven by advanced US programs to seek more advanced weaponry of their own. Soviet military writings have complained about the rising cost of weapons development and production, indicating Moscow's sensitivity to the problem. As the burden grows, the Soviets will be forced to look at alternatives—raising defense procurement budgets at the expense of other elements of defense, reducing the quantity of weapons purchased, or raising the defense budget relative to the economy. While the Soviets have historically relied on innovative simplifications in design to reduce unit costs, the use of more advanced technology probably precludes this alternative. In spite of escalating costs, current Soviet commitments to pursue high-technology programs such as the ABM, more advanced avionics systems for aircraft, weapons-grade lasers, and more sophisticated SSBNs indicate a willingness thus far to pay the price. []

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¹ See articles "Soviet Design and Production Practices in the Aerospace Industries" and "The Importance of Western Technology to Soviet Defense Industries," in this issue. []

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Other Topics

Metalworking Technology in the USSR: Problems and Prospects

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Moscow's efforts to raise industrial productivity by modernizing its machine tool industry are impeded by traditional manufacturing practices as well as by problems with the new technology. Much of the industry's current output consists of general purpose tools that are relatively inexpensive to produce but do not meet the needs of special purpose or complex production in a technologically changing society. The need to service a huge repair and spare parts sector (itself the result of poor quality in original equipment) and to replace the aging portion of the huge Soviet machine tool industry creates great pressure for continued large-scale production of conventional models.

The USSR also has problems producing automated machine tools and incorporating them into its industrial production system. The industrialized West has moved from the simpler numerically controlled (NC) two-axis point-to-point machines to multiaxis contouring models and, in the late 1970s, to widespread use of computer-operated (CNC) machinery. Soviet participation in this technological revolution in metalworking has lagged because of the backwardness of Soviet electronics and computer technology, managerial and structural rigidities reinforced by the Soviet incentive system, and a policy of concentrating resources on the mass production of simple models, such as NC two-axis point-to-point machines.

Despite some success in following the Western lead by shifting more production to complex metalforming tools¹ (with a cutback in general purpose metalcutting

tool production), the product mix of the machine tool inventory, has not changed substantially. As a result, the USSR now faces not only a still lagging tool modernization but shortages of conventional machinery as well.

Proponents of Modernization

The January issue of a leading Soviet economic journal² was devoted to an assessment of the technological level and production problems in the metalworking machinery sector. The 124-page issue contains special reports, interviews with officials, and the stenographic report of a conference of experts held in Ivanovo.

The contributors to the volume—government officials, plant managers, and other important figures in the planning, R&D, and production of advanced automated metalworking machinery in the USSR—have a professional stake in reforming the organization, management practices, and technology of the industry along Western lines and, if necessary, importing large amounts of Western machinery, components, and know-how to accomplish this goal. Their conception of the strategy to be followed in modernizing the metalworking machinery sector is summarized in an article by S. A. Kheynman, chief of the Institute of Economics of the Soviet Academy of Sciences, who

¹ Metalforming tools, such as hydraulic presses, precision forging machines, and stamping machines waste less metal and are more versatile and cost efficient than metalcutting equipment.

² *Ekonomika i organizatsiya promyshlennogo proizvodstva* (Economics and Organization of Industrial Production, EKO).

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is perhaps the most widely published authority on Soviet machine tool modernization.³

Recommendations for Upgrading Soviet Machine Building

The consensus of the participants at the Ivanovo conference was that the USSR should adopt Western industrial production patterns and make major organizational changes in its metalworking machinery industry. These include centering primary responsibility for modernization in the machine-building industries by:

- Abolishing the prevailing system of producing machine tools in multipurpose plants.⁴
- Establishing a nationwide infrastructure of small-to-medium-size plants, employing 28 to 40 persons each, devoted solely to the manufacture of specialized machine tools and parts.
- Instituting a service industry of small-to-medium-size plants to serve users directly, as in the West.
- Stepping up the replacement rate from the pre-1981 2-percent level to 4 percent.
- Increasing vastly the production of key state-of-the-art components such as instruments, controllers, programing devices, and state-of-the-art cutting tools (diamond and sintered carbide).

³ Kheynman highlights Soviet problems by comparing recent Soviet and Western metalworking experience. He documents the greater efficiency and sophistication of metalworking equipment in the West by showing that:

- In 1978 roughly one-third of the machine tools in the US, Japanese, and West German inventories were of the metalforming type, compared with 20 percent for the USSR.
- The poor finishing quality in the USSR stems not only from the composition of the Soviet inventory itself, but from the products used in machining. The USSR uses mainly cast billets and bars, which require greater use of metalcutting than metalforming technology. The USSR lags behind the West in sheet metal production and has relatively few plastic molding machines.
- In the 1970s the rate of replacing obsolescent and wornout machinery was about 2 percent in the USSR as compared with 5 percent for the United States and 7 to 9 percent in West Germany.
- In the West, product specialization is extensive and machine building is supported by a vast infrastructure of secondary producers of specialized parts and components. In the USSR, the specialized machine-building plants produce less than half of the machine tools; nonspecialized plants and repair shops produce the rest.

⁴ The volume has much information on this practice. A striking example is Leningrad's Red Proletariat Plant, a major producer of advanced machine tools, which turns out tens of thousands of mowers on the side.

- Shifting more funds away from the large-scale production of conventional tools to increased production of advanced tools and their supporting infrastructure.

The journal offers extensive evidence that technological deficiencies and gaps in production have forced the USSR to continue its heavy reliance on imports. Total Soviet imports of machine tools are four times greater than exports.

The contributors differ, however, in their assessments of the impact on the USSR of such large, critical imports of metalworking machinery. A minority believes that imported state-of-the-art machinery and better conventional tools do not contribute to the long-range development of indigenous production capability and make the USSR dependent on foreign supply. Most are willing to import machines and components that are in short supply, not available in the quality required, or cheaper abroad. Some would agree with the view of N. Smelyakov, Deputy Minister for Foreign Trade, who recently called for more Soviet involvement in Western technology transfer and argued that the acquisition of foreign licenses and the purchase of state-of-the-art Western technology would help the USSR become a top producer of advanced metalworking machinery.

Pressures for Maintaining Established Production Practices

The thrust for modernizing is balanced by powerful pressures in the USSR for maintaining traditional strategy in the machine-building industry. This becomes clear from the remarks of the director of Gosplan's⁵ machine tool department, Lev Nikolayevich Snovskiy. According to Snovskiy, the pressures for the maintenance of the traditional metalworking machinery system are greater and more widespread than those for innovation. He stated, for example, that when a new plant is established, it is still equipped with machines having manual controls, other conventional metalworking equipment, an oversupply of available parts, and machines that are larger than needed.

⁵ State Planning Committee of the USSR.

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Gosplan thus operates on the horns of a constant dilemma, planning investment for modernization while striving to satisfy those who operate the vast conventional machine-building system in the USSR. The planners, however, can satisfy neither those pushing for an increase in the production of advanced machine tools nor those wishing to maintain established production quotas for conventional tools. Advanced metalworking equipment is still produced too slowly, and the cutback since 1978 in production of metalcutting tools is causing shortages in lathes, milling machines, and other heavy machine tool equipment.

Conclusion

Innovation in the metalworking industry now has a permanent place in the Soviet industrial system. Soviet planners and policymakers are committed to some degree of upgrading in the metalworking industry. There is also a sizable group of both researchers and practitioners whose work is institutionally embedded and whose views, research, and experience find expression in trade journals and even in the central press. However, their work is inhibited by an industrial establishment still heavily committed to traditional manufacturing practices.

Since the late 1970s, the modernization of the machine tool sector, on which all metalworking depends, has been viewed as critical for the Soviet economy. There has been a steep decline in the growth of overall industrial labor productivity since the early 1970s, from 4.4 percent in the first half of the decade to 1.3 percent in 1981. Because of the rapid decline in the growth of the population of working age, the Soviets now expect labor-saving machinery to achieve the increase in productivity and to improve performance and output in critical sectors of the economy. These expectations may not be fulfilled, however. Since the late 1970s, the production of conventional machine tools, still the backbone of the industry, has fallen. The production of advanced tools, though increasing at a constant rate of growth, appears insufficient to take up the slack. Thus the USSR is short on both conventional and advanced tooling, and the response has been to rely more heavily on imports. Because of probable reduction in hard currency earnings by the

mid-1980s, however, the Soviet planners will be under considerable pressure to meet future needs for machine tools from domestic sources, and to reduce imports.

Annex

The Case of the Ivanovo Machine Tool Plant

Some of the difficulties and frustrations that Soviet machine builders encounter in modernizing their equipment and plants are described by V. P. Kabaidze, Director of the Ivanovo Machine Tool Plant, in a report about his efforts to change the plant from a repair facility for the Sverdlov Machine-Building Association in Leningrad into one of a handful of manufacturers of state-of-the-art machining centers in the USSR.⁶

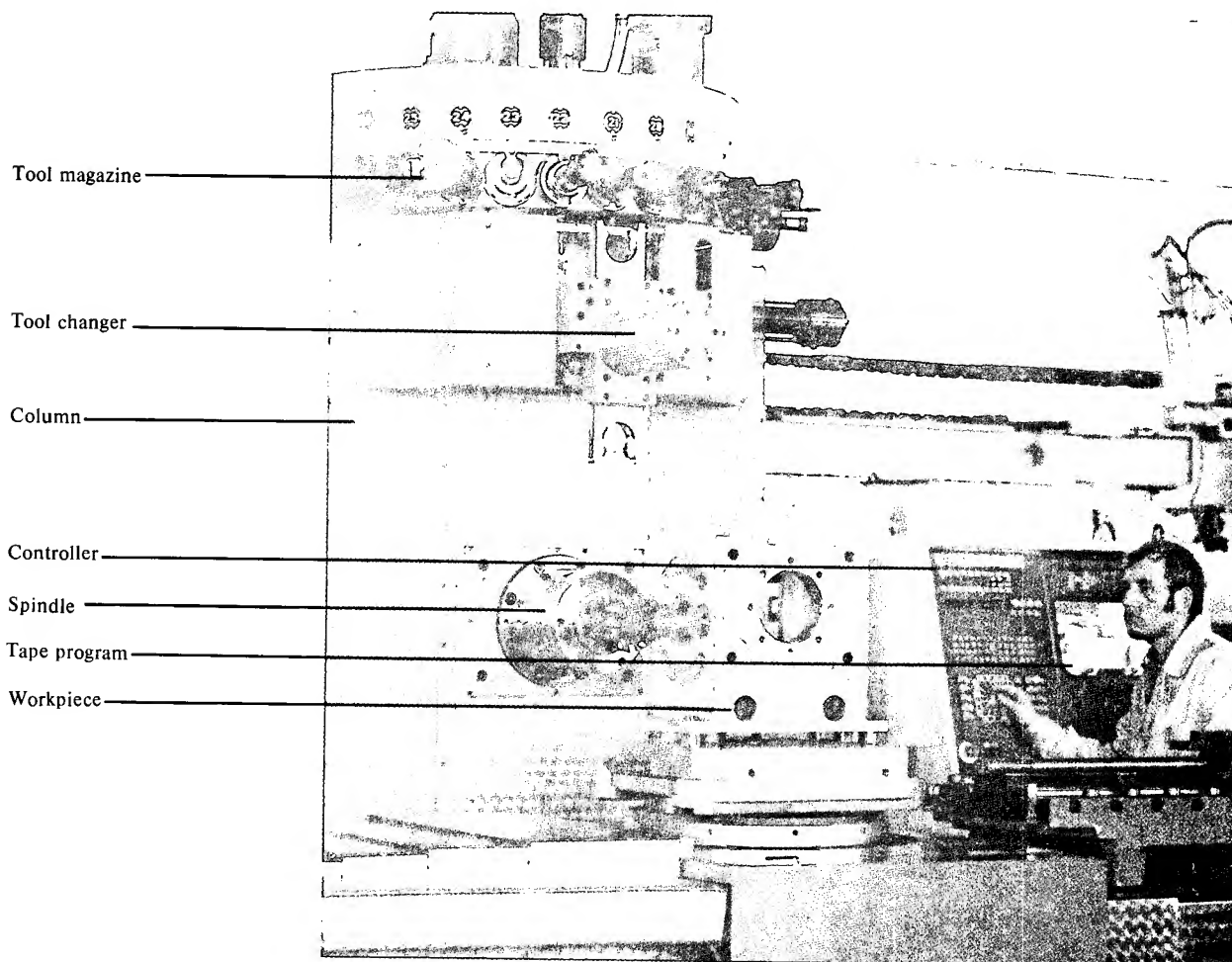
Kabaidze's account shows how unusual managerial initiatives and all-out plant modernization efforts collided with powerful ministerial conservatism and established Soviet industrial practice over a 10-year period. Kabaidze, backed by his parent plant in Leningrad and his party organization, set up a long-range plan to manufacture NC machine tools in the early 1970s. He purchased NC machines and components from Japan, West Germany, and Switzerland and produced the first NC machine tool prototype in 1973. In 1975, after returning from the International Tool Exhibition in Paris, he realized that machining centers had the greatest potential for the marriage of machinery and electronics. With the help of his backers and a Siemens control system bought from West Germany, he built the first machining center, the IR 500 (see photograph). As of January 1982 the plant had built 863 metalcutting machine tools, of which 130 had numerical control and 40 were machining centers. Half of the NC tools are used in the plant itself, and 10 machining centers have been sold abroad. While the plant is not yet a large producer of either NC machines or machining centers, it is well known in the USSR.

⁶ This account is supplemented by a report by V. Ya. Maximov, chief of the plant's technical-programing division, in EKO, pp. 107-109, and by a lengthy article published in the national press by L. Gladysheva and V. Shilov, "Vneplanovaya initsiativa," *Sovetskaya Rossiya*, 13 September 1982, p. 2.

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The IR 500 MF4 Horizontal Machining Center Produced at Ivanovo



A machining center is perhaps the most efficient and versatile machine tool combining electronics and machinery. In the past, a workpiece such as an engine block had to be drilled, milled, bored or threaded on two or three different machines. A machining center can perform all of these functions on the same workpiece, with great savings in labor and time.

The machining center is a complex integrated system with 20 or more tools attached. The workpiece is set on the table. The tool changer picks up a new tool from the magazine, removes the old tool from the spindle, and replaces it with the new one. The column moves along three axes (up and down, sideways, and forward), and the table with the workpiece on it can turn. All motion is produced electronically and dictated by a program inserted into the controller. The machining center in the photograph is the basic prototype produced by the Ivanovo plant. Note that the controller is from Bosch, a major electronics firm in West Germany.

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Kabaidze has had to engage in an unusual struggle to meet his goals. The plant has never had its plan for moving into series production of machining centers approved formally by its ministry. The director has broken with several Soviet managing practices, including the budgetary, which in the USSR still rewards conventional machine tool production. Indeed, in the past five years the plant lost 2 million rubles in incentive funds, and members of its engineering and technical staff lost 1,800 rubles each in bonus money. The enormous costs for electrical components and service, which are not built into the usual budget for machine tool plants, forced the plant to underfund housing, vacations, and other employee benefits, causing an exodus of 50 percent of its staff. Given these difficulties, no one has tried to emulate the example of Ivanovo.



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Western Technology and Polish Production of Military Transport Vehicles for the USSR [REDACTED]

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Poland's giant Huta Stalowa Wola Steel and Machine Plant, which has benefited from Western financing and technology since the early 1970s, is now producing general purpose armored tracked vehicles (MT-LBs).¹ This plant has produced military equipment in the past, but its production of MT-LBs is part of a growing Polish involvement in producing tracked vehicles for the USSR. [REDACTED]

Military Production at HSW

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In the past, HSW has produced military equipment including chassis for the ATS-59 medium tracked artillery tractor, which were shipped to Bumar Labedy Mechanical Works—the Polish tank plant—for final assembly.³ In addition, HSW produced gun breech and barrel assemblies for the Polish T-55 tank and towed artillery pieces for domestic use and for export to Third World countries. HSW's role in military production apparently increased in the late 1970s, when the USSR laid requirements on Poland for production of both civilian and military tracked vehicles. The Soviets designated the Labedy plant as a producer of T-72 tanks for the Warsaw Pact countries, which forced the plant to retool and to relinquish production of the less sophisticated tracked prime mover to HSW.⁴ [REDACTED]

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cent to the assembly plant (figure 17).

² In the past decade, HSW has shipped pipelaying tractors to the USSR. It is highly probable that many of the new tractors will be shipped to the USSR for pipeline construction. [REDACTED]

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³ ATS-59 production was estimated at over 1,000 vehicles annually, of which 90 percent were exported to the USSR. Production was scheduled to be phased out in 1981 because of increasing shortages of raw material and to provide skilled labor for producing T-72 tanks. [REDACTED]

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⁴ In retooling for T-72 production, the Labedy plant purchased Western equipment, including a numerically controlled (NC) punchmaster press from the United States, a bending machine and seam welder from Belgium, spinning lathes and testing devices from Holland, and an NC pipe-bending machine from Sweden. [REDACTED]

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¹ *Mashina transportnaya logkaya boyevaya* [REDACTED]

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SOV UR 82-005
May 1982

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The MT-LB  is an extremely versatile vehicle. It was developed from the MT-L, a light tracked vehicle designed for geological research in the Far North. The MT-LB was first seen with Soviet troops during the Dvina maneuvers of early 1970. The Soviets have used variants of the MT-LB chassis in

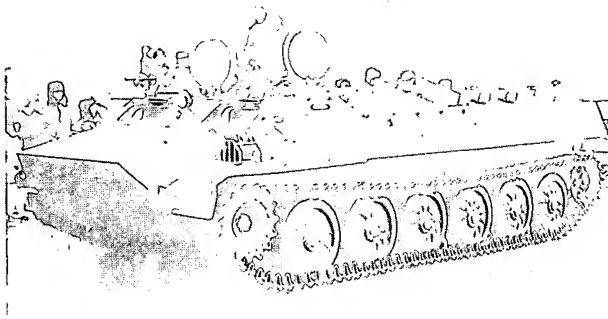
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Figure 2
MT-LB Multipurpose Tracked
Vehicle



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over 15 different vehicles, including an armored personnel carrier, an artillery prime mover, a transport vehicle for the Big Fred radar, a transporter-erector-launcher (TEL) for the SA-13 missile, four different command and artillery support vehicles, and the 122-mm self-propelled gun. Although not state-of-the-art equipment, the MT-LB incorporates proven components and has good mobility.

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Soviet Trade Unions: Striking a New Balance

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The emergence of Solidarity and the ensuing political crisis in Poland have caused Soviet leaders to reexamine their own trade unions, with an eye toward improving the image of the unions among Soviet workers. In the past year and a half, the head of the Soviet trade unions has been purged, and the unions have been instructed to show more concern for their members and to take a more active role in factory management.

Soviet trade unions traditionally have been entrusted with the often conflicting tasks of boosting production and improving the workers' welfare. The priority attached to each of these tasks has varied over the years, but during the 1970s the emphasis was increasingly on production responsibilities. Since 1980, however, events in Poland have helped to reverse this trend. Accounts of the March 1982 All-Union Congress of Trade Unions suggest that a new balance may in fact have been struck, giving greater weight to the union's role in improving the workers' welfare.

The Role of Soviet Trade Unions

Trade unions represent the largest mass organization in the USSR and claim a membership of 130 million people or about 98 percent of the total work force. In return for dues of 1 percent of monthly wages, members receive housing, medical, welfare, and wage benefits unavailable to nonunion workers. The unions act as transmission belts linking the party with the majority of workers who are not party members. Officials do not view their role as representing the interests of the workers vis-a-vis the employer, but as part of a troika working with managerial and party colleagues at the factory.

Unions, in theory, have the power to influence wages, norms, and national labor policies, but their role has been largely advisory. They do exercise some authority in resolving disputes and in enforcing management compliance with labor legislation through a complex mediation process. But union leaders must decide which issues to press at any given time. When supply

bottlenecks force a manager to ignore overtime regulations to meet production goals, the union committee may choose to overlook juridical rights since the causes are beyond the plant management's control.

Factory trade union committees participate in the assignment of welfare benefits. They help to formulate workers' wages, monitor the distribution of pension funds, and distribute cash benefits payable under the social insurance system for sickness, pregnancy, and maternity, and also passes and vouchers for health and recreation facilities.¹

Debate Over the Role of Trade Unions

The first rumblings of Polish unrest stimulated a discussion in *Pravda* that sought to define more clearly the role of trade unions in Communist societies. A series of articles focused on the sensitive subject of the relationship between the party and the trade unions. This discussion helped to lay the groundwork for arguments to expand the influence of Soviet trade unions.

The first article, appearing in September 1980, urged unions to be more active in defending workers' rights and interests, but clearly stated that this must be done under the "direct leadership" of the party. An article on 25 December went even further, suggesting that the party's influence over the unions be limited to the persuasive powers of party members who are also union members. A final article in this series took a more doctrinaire view of trade unions, stressing the need to subordinate union activity to the party and emphasizing party control over the unions "in every

¹ Nationally, trade union central committee representatives meet with corresponding ministries to discuss changes in wage rates. The All-Union Council of Trade Unions also maintains a staff of liaison officers in touch with the State Committee on Labor and Social Questions and the State Planning Committee (Gosplan) to lobby for changes in the wage system. Locally, the factory trade union committee can play a role in determining take-home pay through its distribution of profit-sharing premiums and supplementary social service benefits.

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SOV UR 82-005
May 1982

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possible way." Despite the emphasis on party control, each article exhorted the unions to better represent the workers' interests.

Impact of Solidarity on Soviet Trade Unions

Soviet officials responded swiftly to the failure of Poland's official trade unions as defenders of workers' interests. This became apparent almost immediately after the emergence of Solidarity, particularly in the Baltic republics, along the Polish border. At an August 1980 republic party plenum, for example, Lithuanian party leaders criticized local unions for failing to adequately protect workers' rights and complained that the unions were not sufficiently independent of management.

Georgian party chief Shevardnadze, at his republic's January trade union congress, conceded that the Polish leadership's mishandling of official trade unions was a major factor leading to the rise of Solidarity. He emphasized the need to reform Soviet trade unions and cited a poll showing that 40 percent of Soviet workers were dissatisfied with the trade unions' performance in defending workers' interests.

Heightened concern for promoting the unions' role was clearly demonstrated by the strong Politburo turnout at the recent trade union congress, in contrast to the limited attendance by party leaders at the last congress in 1977. During the past year, President Brezhnev and Central Committee Secretary Konstantin Chernenko have stressed the need for improving the work of trade unions.

President Brezhnev had given these efforts a major boost at the CPSU Congress in February 1981 when he criticized the unions for failing to make full use of their legal rights in protecting workers' interests. He called on the party to more vigorously support the unions, and suggested a larger union role in planning and management, as well as personnel matters.

Brezhnev's remarks were the subject of discussion at a March 1981 trade union plenum. Aleksey Shibayev, then trade union chairman, interpreted Brezhnev's speech as a mandate for an "enhancement" of trade union functions. He called on local unions to increase their monitoring of members' living and working conditions while promoting the use of "democratic

principles" at individual enterprises. The plenum's message to Brezhnev declared that workers' interests would be at the "center" of future trade union activity and suggested that the unions should increase their role in the management of individual enterprises.

Central Committee Secretary Chernenko has been the most outspoken party leader in support of Brezhnev. In November 1980, for example, Chernenko stated that the unions' "most important" duty is to defend workers' rights and improve their living and working conditions, and he called on workers to play a "broader" role in monitoring the decisions of factory managers. Chernenko stressed similar themes last fall when he endorsed efforts to make unions more responsive to workers' interests and "guaranteed" them party support in dealing with unresponsive administrators.

Pravda and *Izvestiya* editorials during the past year have repeatedly urged greater attention to workers' needs and encouraged a more active role for the unions. Other articles have reprimanded party organizations for failing to give the unions their full support. *Trud*, the trade union newspaper, organized 10 "open letter days" at farms and factories where workers had the opportunity to meet with officials to voice their complaints.

Trade Union Leadership

A recent change in the stewardship of Soviet trade unions may also underscore the leadership's interest in refurbishing the image of the unions. On the eve of the trade union congress, Aleksey Shibayev, trade union chairman since 1976, was removed from his post and Stepan Shalayev was installed in his place. This change in leadership does not appear to signal any shift in trade union policy. Shalayev's 16 March speech to the trade union congress was remarkably similar in tone to the public statements Shibayev had been making during the past year, stressing the unions' role both in improving workers' welfare and in increasing production. Brezhnev's speech to the congress gave no indication why the change was made; it contained only mild criticism of trade union work since the last congress.

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Unions and the Economy

The leadership is counting on easing the economy's mounting burdens somewhat by raising labor productivity, but its hopes for improvement may be ill founded. Trade unions are being urged to take greater initiative in improving working conditions, upgrading worker morale, boosting farm and consumer goods output, as well as supporting discipline in an effort to motivate workers.

Union leaders consider boosting production advantageous to workers as well as to management, because workers' take-home pay would rise with the increased funds generated by greater output. But productivity is inhibited by high turnover and discipline problems such as absenteeism and alcoholism, which unions are trying to combat. A number of articles have appeared recently, encouraging union efforts to improve working conditions as a necessary step toward solving these problems and thus raising productivity. A prominent economist recently claimed that "a proper social climate" could increase productivity by 20 to 100 percent.

The commitment to raise productivity through incentive and persuasion rather than coercion and punitive measures seems firm, particularly in light of events in Poland. However, union ability to motivate workers is severely limited. First, the generally poor economic situation—marked by chronic shortages of quality foods and other goods and services—has weakened the incentive effect of wage hikes for which the unions might try to claim at least some credit. Second, reflecting the unions' fundamental lack of independence, the programs involving union participation and direction have continued to be aimed at bolstering labor discipline and raising output in ways that conflict with safeguarding or promoting the workers' interests.

A prime example of the two separate, often mutually exclusive roles that unions are expected to play is a comprehensive decree issued in December 1979. It rewards good job performance by providing nonrepayable housing loans for those who have worked for five years or newlyweds who have worked for two years and by increasing increments to pensions and calling for additional leave time for continuous service. However, the decree also advocates disciplinary

action against those who come to work drunk, are illegally absent, or avoid employment. It tries to reduce turnover by requiring one month's written notice of intent to resign from a job.

Other measures aimed at trade unions since the turmoil began in Poland in mid-1980 continue to reflect their bifurcated role. Unions have taken production-oriented actions including:

- Expansion of union participation in factory management, particularly through factory production conferences. The conferences, which are convened twice each quarter, serve as the principal forum for unions and managers to resolve disputes and discuss topics of mutual interest such as improving production techniques. In the past, the conferences have functioned unevenly; moreover, they lack authority to enforce their recommendations. At the March congress, Chairman Shalayev urged more active use of the conferences and stated that management's practice of not consulting the conference in making decisions was "quite inadmissible."
- Expansion of the brigade system of labor organization—a longstanding form of grass-roots autonomy whereby a number of workers contract collectively for a specific project. Although the leadership sees the brigades as a path to raised productivity, they also serve to discipline lax workers through group pressure.

Worker-oriented actions include:

- Encouragement of factory party leaders to side with unions in support of the workers against negligent administrators. During the last 18 months, the press has publicized numerous cases of managers being fired or punished at union initiative for violations of workers' rights, such as illegal dismissals and infringements of safety standards. One account cites 6,000 management officials who were fired in 1980, nine times the published figure for 1976. Chairman Shalayev has also encouraged unions to be more assertive with management.

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- Upgrading, in July, the organization charged with protecting workers' safety to state committee status, and appointment of a former trade union official as its head.
- Promulgation, in January, of a CPSU decree to help improve and widely expand vocational facilities for trade union members.

Thus, the regime manipulates the unions through palliatives and an emphasis on workers' welfare to guard against a situation similar to that in Poland arising in the USSR. Despite these changes, the union position in the Soviet economy remains contradictory and ambiguous.



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Briefs

Industrial Production Through April ☐

Civilian industrial performance in the USSR improved slightly in April, bringing the level of output in the first four months to 0.7 percent above that for the same period in 1981. Labor productivity did not increase at all, and the slight growth in output can be attributed entirely to more industrial workers. Output in five of the 10 branches of industry remains 0.5 to 4 percent below levels reached in 1981. These include ferrous and nonferrous metals, construction materials, processed food, and soft goods. Unless there is eventual improvement in these branches, the plans for capital investment could be doomed and consumer morale could deteriorate further. ☐

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The slight improvement in April is consistent with our forecast of another record low growth of industrial production in the range of 1 to 1.5 percent by yearend. Unless labor productivity resumes its upward course, additional growth will become harder as influsions of new manpower decrease. Much depends on the ability of the machinery sector to rally and supply high-quality equipment to promote labor productivity. ☐

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New Data on 1981 Hard Currency Position ☐

Recently acquired data show that despite the large trade surplus in July-December 1981 the USSR's trade deficit for the year rose to \$4 billion—double the 1980 level. A soaring agricultural import bill, together with a drop in exports, had pushed the deficit up to \$6 billion in the first half of the year. This forced Moscow to draw down assets in Western banks by an unprecedented \$5 billion and to increase borrowing from commercial banks. Moscow's successful push to rebuild assets in Western banks in the second half of the year resulted in a sharp increase in short-term borrowing as well as heavy gold sales. By year's end, the gross hard currency debt had risen by \$3 billion, to \$21 billion, and assets in Western banks amounted to \$8.4 billion. ☐

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Most of the sharp increase in hard currency imports last year was due to higher grain imports. Imports of Western capital equipment, chemicals, and steel other than pipe declined. On the other hand, Soviet exports stagnated as the volume of oil sales fell and the average price of oil rose only slightly. In addition, unrecorded hard currency expenditures appear to have doubled to more than \$5 billion. Perhaps two-fifths of this amount consisted of hard currency aid to Poland and imports from other CEMA countries—mainly meat and grain—that were purchased for hard currency. Much of the remainder probably represented economic credits to less developed countries for purchases of Soviet plant and equipment and short-term supplier credits to developed Western countries for purchases of Soviet oil.

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The continuing Soviet scramble for financing—mostly for grain purchases—and sizable gold sales so far this year indicate Moscow is faced with another large trade deficit. []

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**Soviet Planner Discusses
the Economy** []

[] knowledgeable
Soviets share the view of most Western experts that the prospects for solving the USSR's severe economic problems are dim. []

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- Bad weather is the main cause for the poor harvests in recent years, necessitating extensive imports of farm products.
- Problems are being encountered in the coal and oil industries, with gas being the single hope in the energy field. Gas exports are being counted on to alleviate Moscow's hard currency problem.
- Investment cutbacks will make it nearly impossible to overcome bottlenecks in the economy, including the shortage of railroad rolling stock.
- Soviet workers are poorly motivated and frustrated by a lack of goods on which to spend their wages.
- Economic aid to Poland and large defense expenditures are severely burdening the civilian economy. []

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[] Soviet GNP has grown less than 2 percent during each of the last three years, and an even worse start has been made this year. [] there is growing concern in Moscow about the prospects of the economy, which may prompt further changes in the current five-year plan. []

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**Large Tungsten Imports
Continue** []

The USSR is continuing to buy abnormally large amounts of tungsten, a critical alloy in the manufacture of armaments, drilling equipment, and superhard steel. Soviet imports amounted to about 11,000 tons in 1981, down from the peak of 14,000 tons in 1980, but more than triple average annual imports during the 1970s. The imports supplement growing domestic production—estimated at 9,000 tons last year. We believe that the surge in imports is tied closely to Soviet military programs as well as to oil and gas drilling. Current Soviet imports would support annual production of several million tungsten-based armor-piercing rounds and several hundred thousand tungsten carbide drill bits. Despite hard currency problems, the USSR spent at least \$100 million for tungsten imports in 1981. Moscow has ordered its purchasing agents to continue to give tungsten a high priority. []

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**Soviets Cut Iron
Ore Plan** []

The USSR recently cut the 1985 plan for iron ore production from 275 million tons to 262 million tons. Even this lower target cannot be achieved; we believe that Soviet production of iron ore will, at most, reach 255 million tons by 1985. Shortfalls in iron ore and other raw materials will limit Soviet steel output to 155 million tons by 1985, roughly 10-percent short of the current target for that year. It is only a matter of time before Moscow will be forced to trim the 1985 plan for steel production as well. []

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**Regional Commission
Claims Success
in Improving
Management**

Soviet efforts to improve management of the West Siberian Territorial Production Complex (TPK), which includes the critically important oil and gas deposits of Tyumen' and Tomsk Oblasts, appear to be having some success. In a recent *Pravda* article, the chairman of the USSR Gosplan Interdepartmental Commission for the Development of the West Siberian Oil and Gas Complex, V. Kuramin, touts the Commission's accomplishments in resolving both long-term and day-to-day problems of coordination and planning and calls for even further expansion of the Commission's responsibilities. Furthermore, according to Kuramin, the West Siberian TPK has been expanded to include Novosibirsk Oblast with its large scientific research establishment.

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Kuramin clearly sees the Commission as a prototype for a new form of project management that would allow for a necessary degree of decentralization of supervision while retaining centralized control. Although the Commission, which is located in Tyumen' and includes representatives of local party, government, and economic organizations, now has only advisory authority, it makes its recommendations directly to higher authorities via a corresponding Commission of the Presidium of the USSR Council of Ministers and to USSR Gosplan. If the Gosplan Commission continues to have success, it is likely that similar bodies will be created for other high-priority regional development projects included in the 1981-85 Plan such as the Ekibastuz and Sayan TPKs, the Russian non-black-earth zone, and the Baikal-Amur Railroad. Such a proliferation of regional commissions, however, especially if accompanied by efforts to increase their authority, is likely to run into bureaucratic resistance from the affected ministries.

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